Physics & Astronomy
PHSX 211: General Physics I
Christopher Fischer

Core Goal 1.1
2015 Haufler KU Core Innovation Award Winner

Q1. What evidence does your department / program use to determine whether students are achieving your KU Core goals in this course?

Students in PHSX 211 are required to: (a) analyze the information given in a problem; (b) assess the validity of any assumptions required for the application of a particular concept, equation, or approach; and (c) test the validity of their solution either by demonstrating that it makes physically realistic predictions under certain limits or by deriving it through an independent approach. Particular emphasis in the course is placed on the generality of critical thinking, especially with regards to the changing situations frequently encountered in "real world" science and engineering situations. The evidence of achievement of Goal 1.1 is the students' demonstrated ability to apply critical thinking skills as assessed through a combination of focused quiz and exam questions. The students' performance on quizzes and exams was chosen since these assignments are completed individually and thus allow for assessment of individual student performance. Critical thinking questions are also presented/discussed in class and assigned as homework. However, individual student performance is difficult to assess quantitatively for those assignments (students are encouraged to work together on homework, e.g.) so those results are not included in our analysis/assessment.

Q2. What quantitative format does your department / program use to summarize the degree to which students in this course achieve the KU Core goals?

The department does not have a standard rubric for this course. Instead, individual instructors are responsible for implementing and assessing content in their offering of the course. However, the department has identified an expansive set of quiz and exam questions spanning all topics covered in PHSX 211 that have solutions requiring the successful application of the tasks associated with this learning outcome. All of these questions are qualitative (rank order questions, e.g.) and thus assess the students' ability to think critically about physics concepts, rather than their applied mathematics skills or ability with dimensional analysis. Student achievement of Goal 1.1 is assessed through students' scores on these questions; a minimum sample of ten questions is used in this analysis. These questions are made available to all instructors who teach PHSX 211 and past student performance on these questions is cataloged. Faculty are encouraged to use these questions for their in class discussions, homework, quizzes, and exams. The use of similar questions every semester is also encouraged since doing so increases the uniformity of the assessment of student achievement of the learning goal. The collection of questions together with data on past student achievement is stored electronically on Blackboard and is accessible for all faculty.

<u>Q3</u>. Please describe your evaluation process, including rubrics, metrics, and assignment instruments (e.g. description of the assignments, test questions, final exam, final project, etc.) and how your evaluation aligns to the learning outcomes.

The following are representative examples of the questions used in assessment of the learning outcome. The questions can appear on quizzes or exams.

Two long parallel wires are carrying electricity in opposite directions. The presence of this electricity in the two wires results in a potential energy being created. This potential energy has a dependence on the separation distance between the two wires that can be described using the figure below. The two wires are initially held in place close to each other and then released. After they are released, what will happen?

(A) The two wires will move closer together.
(B) The two wires will remain in position.
(C) The two wires will move farther apart.

System A and System B consist of two blocks connected by a massless rope that moves without slipping over a frictionless pulley; the pulley in System A is massless. When this system is released from rest the 10 kg block will accelerate downwards and the 6 kg block will accelerate to the right. System C and System D consist of a single block attached to a massless rope that moves without slipping over a frictionless pulley; the pulley in System C is massless. Someone pulls down on the rope in System C and System D creating a tension of 98 N in the rope which accelerates the 6 kg block to the right. Rank in order from smallest to largest the magnitudes of the acceleration of the 6 kg block in these systems.

(A) $a_A > a_B > a_C > a_D$

(B) $a_D > a_C > a_A > a_B$

(C) $a_C > a_D > a_A > a_B$

(D) $a_C > a_A > a_D > a_B$

(E) $a_A > a_C > a_B > a_D$

The block, solid cylinder, solid sphere, and hollow sphere in the figure all have the same mass. The cylinder and spheres also have the same radius and roll without slipping. Rank the magnitudes of the translational accelerations of the objects as they move down the ramp. You may assume that there is no dissipation of energy due to friction for any of these systems.

(B) $a_A > a_D > a_C > a_B$

(C) $a_A > a_B > a_C > a_D$

(D) $a_A > a_D > a_B > a_C$

(E) $a_D > a_C > a_B > a_A$

The figure shows 4 different oscillating systems. The object in system C and system D is a uniformly dense solid cylinder which rolls without slipping around an axis through its center as it oscillates. All springs are identical and the mass of each oscillating object is the same. Rank in order from largest to smallest the angular frequency of the oscillations of the systems.

(A) $w_B > w_A > w_D > w_C$

(B) $w_C > w_A > w_B > w_D$

(C) $w_B > w_D > w_C > w_A$

(D) $w_C > w_A > w_D > w_B$

(E) $w_B > w_D > w_A > w_C$

Q4. Please provide a quantitative summary of student achievement in this course in the assessment period. This may take the form of a distribution of scores over several dimensions of the learning outcome or a single comprehensive assessment of the learning outcome.

KU Core Goal 1.1 assessment questions constitute 60% of the student's final course grade and, as discussed previously, are used (with some variation) every semester to evaluate both the performance of the students in achieving this learning outcome and the performance of the course in enabling the students to achieve this learning outcome. Specifically, a student's achievement of this learning goal/outcome is assessed using the average score obtained by the student on these identified questions and exercises.

The number of students in the course whose average score for all identified learning goal/outcome questions is shown in the table below.

Semester	Excellent > 89%	Very Good 80% to 89%	Good 70% to 79%	Satisfactory 60% to 69%	Unsatisfactory < 60%
Spring 2014	86	105	132	43	22
Summer 2014	7	11	13	5	4
Fall 2014	30	33	42	14	9
Spring 2015	35	47	29	15	11
Summer 2015	9	14	10	6	2

The average student score for all identified learning goal/outcome questions was:

Semester	Average Score	Enrollment
Spring 2014	77%	388
Summer 2014	80%	40
Fall 2014	74%	128
Spring 2015	76%	137
Summer 2015	75%	41

Dimension	% of "Exemplary Achievement" (4)	% of "Good Achievement" (3)	% of "Satisfactory Achievement" (2)	% of "Basic Achievement " (1)	% of "Outcome Not Achieved" (0)
Overall assessment of learning outcome	23%	29%	31%	11%	6%

<u>Q5</u>. What percentage of the students achieved at least basic overall competency in this learning outcome? Please also briefly state how you have defined basic competency for this purpose.

If basic overall competency of student achievement is defined as satisfactory achievement or above in our metric (greater than 60% of questions answered correctly), then our data indicates that 94% of students in PHSX 211 have achieved basic overall competency.

Our department has also set its own internal standard for assessing achievement of the KU Goal 1.1 outcome as part of our department's program assessment procedure. The course's achievement of this learning goal/outcome is assessed using the average of the student averages for KU Goal 1.1 assessment questions for the entire enrollment of the course. Our department has established a class average of 75% as the threshold for achievement of this learning goal/outcome. The weighted average (weighted by enrollment) for PHSX 211 for this assessment period was 76.3%, which meets this threshold.

<u>Q6</u>. Provide a descriptive summary of student achievement in meeting the Goal's learning outcome.

PHSX 211 is taught as a hybrid course. There is no formal lecture during class. Instead, students review online material, such as videos and pre-class quizzes that have been developed by the faculty and posted on Blackboard, as well as completing reading assignments from the textbook. Class time is devoted to active learning exercises; specifically: conceptual quizzes, discussion, and problem solving (in groups). It is through these conceptual quizzes and in-class exercises that the faculty model critical thinking skills for the students and work directly with the students to develop these same skills. For example, early in the semester the students discuss whether a car has better gas mileage with the air conditioning turned on or turned off. All of the students have an answer for this question based on their personal experience, but the instructor guides them to use the principle of energy conservation to construct their answers. The students are similarly guided to use energy conservation as part of their critical thinking strategies in several additional conceptual questions before their first exam. The first exam contains several conceptual questions, none of which the students have encountered previously as part of the course, but all of which require critical thinking using energy conservation as a basis. An example question is:

The figure below shows 4 different systems of moving objects. For A and C the objects are in freefall. The pulley and rope in both B and D are massless. Rank in order from largest to smallest the magnitude of the acceleration of these systems.

(A) $a_A < a_B < a_C < a_D$

(B) $a_B > a_A = a_C > a_D$

(C) $a_A = a_C > a_B > a_D$

(D) $a_D > a_C = a_A > a_B$

(E) $a_D > a_B > a_C > a_A$

The critical thinking questions on the first exam provide a baseline in establishing the students' critical thinking skills at the beginning of the course. The application of critical thinking using energy conservation and other conservation laws, such as momentum conservation, is continually modeled by the faculty and practiced by the students throughout the remainder of the semester. Students are repeatedly tested on their critical thinking skills using similar conceptual questions on all subsequent exams. On the final exam more challenging critical thinking questions, such as that shown below, are included.

A uniformly dense solid cylinder is rolling without slipping down a semicircular track as shown in the figure. A uniformly dense solid sphere is rolling without slipping down an identical track. Each object will fly off its track at a characteristic angle q. Which object will have a larger value of q? You should assume that any losses of energy with changes in position due to friction will be identical for both objects.

(A) Sphere
(B) Cylinder
(C) The angle is the same for both objects.

The majority of students (72% enrollment weighted average for this assessment period) show an improvement in their exam-averaged score on critical thinking skills between the first exam and a smaller majority (53% enrollment weighted average for this assessment period) show a continual trend of improvement in their exam-averaged score on critical thinking skills throughout the semester. This evidence supports the quantitative analysis that most of the students achieved at least a basic ability in critical thinking.

Q7. The intent of this assessment is to promote improvement in meeting KU Core goals for greater numbers of students. What changes are suggested by the data and results you report above that would improve the achievement of this learning outcome?

Although the threshold for learning goal/outcome achievement was met, there is always room for continued improvement. A simple modification to the course would be to include more modeling of critical thinking by the faculty during class. Perhaps a more useful and longer-term change would be to increase the pool of critical thinking questions available to faculty teaching the course. This suggestion will be discussed further (and likely implemented) as part of the department's regular KU CORE review procedure. According to this procedure all assessment material for all courses, either as part of the KU Core assessment or the program assessment, are reviewed by the department's Undergraduate Committee, and, ultimately, by the Departmental Assembly. The faculty teaching these courses, the course GTAs, and the UTAs then work on adjustments to the courses in response to the feedback obtained from these groups. Furthermore, during the regular meetings between the instructor, GTAs, and UTAs, the latter two groups provide feedback about the current status of the course to the instructor.